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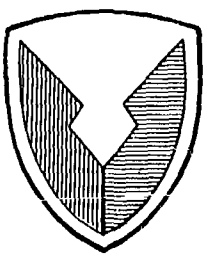

CCL REPORT NO. 156

THE DEVELOPMENT OF AN IMPROVED COOLING SYSTEM CORROSION INHIBITOR

BY

JAMES H. CONLEY

AMCMS CODE NO. 5025.11.803
DA PROJECT 1-A-0-24401-A-109

10 FEBRUARY 1964

ABERDEEN PROVING GROUND
MARYLAND

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U.S. Army Coating and Chemical Laboratory
Aberdeen Proving Ground
Maryland

UNCLASSIFIED

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ABSTRACT

The object of this study was to develop an improved inhibitor combination for use in water and ethylene glycol type antifreeze mixtures.

Bench corrosion tests were used for initial screening. The more promising coolant and inhibitor combinations were then evaluated in simulated service tests. One combination was chosen for vehicle field tests.

An improved inhibitor was found which consists of borax, mercaptobenzothiazole and disodium phosphate.

It is recommended that the results of this study be used as a basis for the revision of Federal Specification O-I-490.

I. INTRODUCTION

Aberdeen Proving Ground, Maryland, was directed by AMC program directive AMCMS Code 5025.11.803, dated 15 October 1962, to investigate improved antifreeze mixtures.

Due to the automotive industry's trend toward higher horsepower engines which produce more heat, and the introduction of aluminum engine components, there is a need for improved antifreeze coolants which have improved corrosion and thermal stability. In the event that these types of vehicles should enter the military supply system, it was considered advantageous to modify Federal Specification O-I-490, Inhibitor, Corrosion Liquid Cooling System. Previous tests (CCL Reports No. 125, 145 and 155) indicated that when aluminum components were used in conjunction with other metals, current specification inhibitors did not always offer adequate corrosion protection after extended use. Increased amounts of mercaptobenzothiazole (MBT) are necessary.

Problems exist when antifreeze compounds containing mercaptobenzothiazole are packaged. Therefore, the present study was directed toward improving Federal Specification O-I-490, Corrosion Inhibitor for use as an additive to water and ethylene glycol type antifreeze mixtures rather than changing Federal Specification O-A-548a, Type I and Military Specification MIL-C-11755A. No packaging problems are involved with the improved inhibitor.

II. DETAILS OF TEST

A. Bench Corrosion Test

Bench corrosion tests were conducted in accordance with the procedure outlined in LSD Report No. 205, dated 26 February 1964. This procedure involves the immersion of a set of six metal test specimens (cast iron, aluminum, copper, solder, brass, steel) in a glass flask containing the test solution. The solution is aerated and refluxed at 180°F. for 192 hours, after which the metal test specimens are examined for evidence and extent of corrosion.

B. Simulated Service Test

This test involves variations of the test outlined in LSD Report No. 205, dated 26 February 1954. The test consists of mechanical units arranged to permit the test solution to be circulated in a closed system at a controlled circulation rate and temperature.

In this study the unit contained an aluminum, steel or cast iron reservoir, or block and aluminum or brass radiator. The pump was driven by an electric motor. Test temperature was maintained at 180°F. ± 5°F.

Metal test specimens arranged on a rod or bracket and suspended in the reservoir were examined for evidence and extent of corrosion.

C. Vehicle Field Tests

Two test vehicles and two facility vehicles were selected for field evaluation of one inhibitor and coolant combination. The cooling systems were

drained and flushed. All unserviceable parts were replaced. The cooling systems were then filled with the test solutions. Periodic physical and chemical checks were made to locate any leaks in the cooling system and determine amount of inhibitor depletion.

D. Test Solution

Water, aqueous solutions of Specification O-A-548a Antifreeze, and Specification MIL-C-1755A Arctic Antifreeze were tested with additional inhibitors. Aqueous solutions utilized were distilled water, ASTM Corrosive Water containing 100 ppm each of chloride, sulfate and bicarbonate, and a synthetic hard water containing 342 ppm as calcium carbonate.

E. Numerical Rating System

A numerical rating system has been devised (LSD Report No. 205) which allows a comparison of test results based on weight loss and visual evidence of corrosion of the metal test specimens. An arbitrary value of 21 was selected as the point of demarkation between satisfactory and unsatisfactory results in the bench corrosion test and a value of 35 was chosen as the point of demarkation in the simulated service test.

III. RESULTS OF TESTS

Results of tests are listed in Tables I thru III of Appendix B. All solutions performed satisfactorily in the bench corrosion tests (Table I). The modified O-I-490 which contains borax, mercaptobenzothiazole, and disodium phosphate (see Appendix A), lessens the weight loss on aluminum in almost every instance (Table I). The modified inhibitor also performs satisfactorily in water containing 100 ppm of Cl^-, $SO_4^=$ and HCO_3^- or a synthetic hard water containing 342 ppm as $CaCO_3$ (Table I).

Simulated service tests show that aluminum weight losses are lessened by the addition of the modified inhibitor. Solder losses are increased in some instances (Table II), although no radiator failure occurred in 2000 hours of operation.

Vehicle field tests indicate no cooling system failures when the improved inhibitor is added as specified in Appendix A. In 34000 miles of operation in facility vehicles over a period of 13 months, neither solution loss nor inhibitor depletion were excessive (Table III).

IV. DISCUSSION AND CONCLUSIONS

Previous studies showed that corrosion may be experienced in aluminum/cast iron systems after extended use. Tests conducted during this investigation indicated that the modification of O-I-490 would provide improved aluminum protection without imparting serious corrosion problems to the other cooling system metals. The disodium phosphate is chiefly responsible for this improvement.

The mercaptobenzothiazole pacifies the metal surfaces. The increased amount would insure a large enough quantity to cover the entire exposed surface area in the cooling system.

Problems exist in the packaging of antifreezes containing mercaptobenzothiazole. Therefore, the inhibitor must be packaged separately and added in the quantities needed. The improved inhibitor described herein will be packaged dry in six ounce containers, in the same manner as the present O-I-490 inhibitor.

Quantities of the inhibitor to be added to the coolant systems are based on the solubilities of borax in different coolant media. It would be the duty of using personnel to correlate the optimum amount of inhibitor to be added (10 oz. to 21 qts. of water) with inhibitor package size. This will depend on cooling system capacity and the amount of water present. The amount of water will be dictated by the freezing protection desired.

This inhibitor has exhibited improved performance in tests involving hard water and corrosive water. The combination of ingredients specified gave optimum results in tests conducted. Precipitates which form in these waters are not detrimental to the cooling system metals and do not physically interfere with cooling system operation.

The ingredients of this improved inhibitor are readily available and cost-wise would be in the same range as the presently specified inhibitor.

V. RECOMMENDATIONS

It is recommended the Federal Specification O-I-490, Inhibitor, Corrosion, Liquid Cooling System be revised to include the formulation developed herein.

VI. REFERENCES

1. Authority: AMC Program Directive, AMCMS Code 5025.11.803, dated 15 Oct 62.

2. Federal Specification O-I-490 Inhibitor, Corrosion Liquid Cooling System, dated 27 Nov 1957.

3. Federal Specification O-A-548a, Antifreeze, Ethylene Glycol, Inhibited, dated 30 Dec 1958.

4. Military Specification MIL-C-11755A, Compound, Antifreeze, Arctic Type dated 17 July 1957.

5. Laboratory Service Division Report No. 205 - Development of a Suitable Laboratory Bench Corrosion Test for Antifreeze Compounds and Inhibitors, dated 26 February 1954.

6. CCL Report No. 125 - Compatibility of Coolants with Automotive Cooling Systems Containing Aluminum Components - 1st Report, dated 21 June 1962.

7. CCL Report No. 145 - Final Report on Compatibility of Coolants with Automotive Cooling Systems Containing Aluminum Components, dated 14 June 1963.

8. CCL Report No. 155 - New Corrosion Inhibitors for Antifreezes, dated 16 January 1964.

APPENDICES

APPENDIX A

Improved Inhibitor Composition and Intended Use

IMPROVED INHIBITOR COMPOSITION AND INTENDED USE

70.0% $Na_2B_4O_7 \cdot 10H_2O$

14.0% Mercaptobenzothiazole

16.0% $Na_2HPO_4 \cdot 7H_2O$

It is intended for use in water and Federal Specification O-A-548a, Type I, antifreeze/water solutions at the optimum rate of 10 ounces of inhibitor to 21 quarts of water.

It is also intended for use in MIL-C-11755A at the optimum rate of 10 ounces of inhibitor to 21 quarts of solution as packaged.

APPENDIX B

Tables

TABLE I

BENCH CORROSION SCREENING TESTS

Test No.	1	2	3
Coolant	100% distilled water	100% distilled water	100% distilled water
Added Inhibitor	1.5% O-1-490	0.06% Na_2HPO_4 0.10% M.B.T. 1.70% borax	0.12% Na_2HPO_4 0.20% M.B.T. 1.00% borax
pH Before	---	---	8.92
pH After	---	---	8.82
RA Before	---	---	5.80
RA After	---	---	5.80
Visual Inspection and wt. change mg/sq cm			
Solder	Sl. stain -.62	Sl. stain -.75	Stained -.13
Steel	Sl. stain +.20	V. sl. stain .00	Stained +.01
Aluminum	Severe pitting -8.01	Black -3.46	Black -1.20
Cast Iron	Sl. stain +.20	V. sl. stain +.11	Stained +.01
Brass	V. sl. stain +.19	OK +.04	Sl. stain +.05
Copper	Med. stain +.13	V. sl. stain +.03	Stained +.02
CCL Rating	25	23	19

TABLE I

BENCH CORROSION SCREENING TESTS (CONTINUED)

Test No.	4	5	6
Coolant	100% synthetic hard water	100% ASTM corrosive water	100% MIL-C-11755A
Added Inhibitor	0.12% Na_2HPO_4 0.20% M.B.T. 1.00% borax	0.12% Na_2HPO_4 0.20% M.B.T. 1.00% borax	----
pH Before	8.92	8.85	7.18
pH After	8.72	8.85	7.42
RA Before	5.90	5.90	7.90
RA After	5.50	5.90	7.65
Visual Inspection and wt. change mg/sq cm			
Solder	Med. stain -1.73	Sl. stain -.47	Sl. pitting -.07
Steel	Sl. stain +.02	Sl. stain +.03	Sl. stain -.01
Aluminum	Black -4.93	Black -2.69	Heavy pitting -.16
Cast Iron	Sl. stain +.03	Sl. stain +.03	Sl. rust -.05
Brass	Sl. stain +.02	Sl. stain +.09	Sl. stain -.02
Copper	Sl. stain +.02	Sl.-Med. stain +.04	Sl. stain +.02
CCL Rating	25	22	13

TABLE I

BENCH CORROSION SCREENING TESTS (CONTINUED)

Test No.	7	8	9
Coolant	100% MIL-C-11755B	100% MIL-C-11755A	100% MIL-C-11755A
Added Inhibitor	0.06% Na_2HPO_4 0.10% M.B.T. 1.70% borax	0.024% Na_2HPO_4 0.04% M.B.T. 0.20% borax	0.036% Na_2HPO_4 0.06% M.B.T. 0.30% borax
pH Before	7.40	7.10	7.08
pH After	7.20	7.15	7.08
RA Before	17.40	8.30	8.80
RA After	16.70	8.00	8.70
Visual Inspection and wt. change mg/sq cm			
Solder	OK .00	OK -1.40	OK -1.40
Steel	OK .00	Sl stain +.01	Stained +.01
Aluminum	Pitted pt contact .00	OK .00	OK +.01
Cast Iron	OK .00	Sl. stain -.05	Stained -.05
Brass	OK .00	Sl. stain +.01	V. sl. stain +.03
Copper	V. sl. stain .00	Sl. stain +.02	V. sl. stain +.02
CCL Rating	8	16	16

TABLE I

BENCH CORROSION SCREENING TESTS (CONTINUED)

Test No.	10	11	12
Coolant	100% MIL-C-11755A	100% MIL-C-11755A	50/50 O-A-548a distilled water
Added Inhibitor	0.048% Na_2HPO_4 0.08% M.B.T. 0.40% borax	0.12% Na_2HPO_4 0.20% M.B.T. 1.00% borax	----
pH Before	7.15	7.22	7.50
pH After	7.05	7.10	7.48
RA Before	9.50	13.80	7.00
RA After	9.30	13.40	7.00
Visual Inspection and wt. change mg/sq cm			
Solder	OK +.59	OK -.01	OK -.35
Steel	Stained +.01	OK .00	OK -.02
Aluminum	OK -.01	OK -.02	Black -.40
Cast Iron	Stained -.10	OK +.01	OK -.13
Brass	V. sl. stain +.01	V. sl. stain +.01	Sl. stain -.01
Copper	V. sl. stain +.02	V. sl. stain +.01	Sl. stain -.01
CCL Rating	15	8	16

TABLE I

BENCH CORROSION SCREENING TESTS (CONTINUED)

Test No.	13	14	15
Coolant	30/70 O-A-548a distilled water	50/50 O-A-548a distilled water	30/70 O-A-548a distilled water
Added Inhibitor	----	Water contains 1.5% O-I-490	Water contains 1.5% O-I-490
pH Before	7.85	7.58	7.90
pH After	7.78	7.49	7.92
RA Before	4.50	11.05	10.50
RA After	4.76	11.05	10.10
Visual Inspection and wt. change mg/sq cm			
Solder	Sl. stain .00	Sl. pitting -.20	Pitted -.13
Steel	Sl. pitting -.30	Sl. stain -.07	Stain & pitted -.02
Aluminum	Mod. pitting -.60	Green -.82	Black -1.40
Cast Iron	V. sl. pitting -.50	Sl. stain +.05	Stain & pitted -.02
Brass	V. sl. stain .00	Sl. stain +.07	Sl. stain +.09
Copper	Med. stain .00	Sl. stain +.05	Heavy stain +.01
CCL Rating	18	18	19

TABLE I

BENCH CORROSION SCREENING TESTS (CONTINUED)

Test No.	16		17		18	
Coolant	50/50 O-A-548a distilled water		30/70 O-A-548a distilled water		50/50 O-A-548a distilled water	
Added Inhibitor	0.06% Na_2HPO_4 0.10% M.B.T. 1.70% borax		0.06% Na_2HPO_4 0.10% M.B.T. 1.70% borax		0.06% Na_2HPO_4 0.10% M.B.T. 0.50% borax	
pH Before	7.50		7.80		7.52	
pH After	7.50		7.80		7.48	
RA Before	16.40		14.00		10.65	
RA After	16.30		13.20		10.60	
Visual Inspection and wt. change mg/sq cm						
Solder	OK	.00	OK	-.08	OK	-.02
Steel	OK	.00	OK	.00	OK	-.02
Aluminum	Grey	-.05	Black	-.15	Grey	-.06
Cast Iron	OK	.00	OK	.00	OK	-.03
Brass	OK	.00	V. sl. stain	+.08	V. sl. stain	.00
Copper	OK	+.02	V. sl. stain	.00	V. sl. stain	-.01
CCL Rating	7		10		9	

TABLE I

BENCH CORROSION SCREENING TESTS (CONTINUED)

Test No.	19	20	21
Coolant	30/70 O-A-548a distilled water	50/50 O-A-548a hard water (342 ppm as $CaCO_3$)	30/70 O-A-548a hard water (342 ppm as $CaCO_3$)
Added Inhibitor	0.084% Na_2HPO_4 0.14% M.B.T. 0.70% borax	0.06% Na_2HPO_4 0.10% M.B.T. 0.50% borax	0.084% Na_2HPO_4 0.14% M.B.T. 0.70% borax
pH Before	7.82	7.45	7.75
pH After	7.78	7.45	7.75
RA Before	8.75	10.40	8.50
RA After	8.70	10.00	8.50
Visual Inspection and wt. change mg/sq cm			
Solder	OK .00	OK -.08	OK -.04
Steel	OK .00	OK +.01	OK +.01
Aluminum	Grey -.06	Grey -.01	Grey -.05
Cast Iron	OK -.13	V. sl. stain -.07	V. sl. stain -.03
Brass	V. sl. stain +.01	V. sl. stain -.01	Sl. stain -.17
Copper	V. sl. stain +.01	Sl. stain +.01	Sl. stain +.01
CCL Rating	10	10	11

TABLE I

BENCH CORROSION SCREENING TESTS (CONTINUED)

Test No.	22	23	24
Coolant	50/50 O-A-548a distilled water	50/50 O-A-548a distilled water	50/50 O-A-548a distilled water
Added Inhibitor	0.06% Na_2HPO_4 water contains 1.5% O-I-490	1.3% O-I-490 0.7% M.B.T.	1.3% O-I-490 0.20% M.B.T.
pH Before	7.52	7.40	7.20
pH After	7.48	7.40	7.20
RA Before	11.50	15.1	15.5
RA After	11.30	---	---
Visual Inspection and wt. change mg/sq cm			
Solder	OK +.02	OK -.09	OK .00
Steel	OK +.01	OK .00	OK .00
Aluminum	Grey -.01	Black -.79	Black -.60
Cast Iron	Sl. stain -.01	Sl. stain +.15	Sl. stain +.25
Brass	Sl. stain +.02	OK +.06	Sl. stain +.05
Copper	Sl. stain +.02	Sl. stain -.05	Sl. stain .00
CCL Rating	10	14	15

TABLE II

SIMULATED SERVICE TEST

Metal Components	Cast Iron Reservoir and Brass Radiator		
Test Number	1	2	3
Coolant	100% distilled water	100% distilled water	50/50 O-A-548a distilled water
Added Inhibitor	1.5% O-I-490	0.12% Na_2HPO_4 0.20% MBT 1.00% borax	----
Total Hours of Operation	2000	2008	*1475
pH Before	9.18	8.82	
pH After	8.90	8.82	
RA Before	13.30	6.20	
RA After	8.50	5.70	
Visual Inspection and wt. change mg/sq cm			
Solder	Heavy stain -10.17	Heavy stain -.70	V. sl. pitting -.44
Steel	Slight stain -.06	Slight stain .00	V. sl. stain -.27
Aluminum	*Pitted -19.72	*Pitted -34.99	Pitted -3.62
Cast Iron	Slight stain +.35	Slight stain +.40	Med. pitting -9.17
Brass	Slight stain +.05	Slight stain -.23	Sl. - med. stain -.17
Copper	Heavy stain +.20	Heavy stain -.31	Med. stain -.95
CCL Rating	29	31	39
*Remarks	Aluminum was badly pitted and the corrosion product was very porous	Aluminum was badly pitted but the surface was hard	Radiator developed a leak after 1475 hrs. of operation

TABLE II

SIMULATED SERVICE TEST (CONTINUED)

Metal Components	Cast iron reservoir aluminum radiator	Cast iron block aluminum radiator	Aluminum block brass & aluminum radiator
Test Number	4	5	6
Coolant	50,50 O-A-548a distilled water	50/50 O-A-548a distilled water	50/50 O-A-548a distilled water
Added Inhibitor	0.06% Na_2HPO_4 0.10% MBT 0.50% borax	0.06% Na_2HPO_4 0.10% MBT 0.50% borax	0.06% Na_2HPO_4 0.10% MBT 0.50% borax
Total Hours of Operation	2133	*1846	2007
pH Before	7.42	7.42	7.42
pH After	7.42	7.55	7.47
RA Before	10.70	10.90	10.90
RA After	9.50	9.50	10.40
Visual Inspection and wt, change mg/sq cm			
Solder	Sl. pitting on edge -2.15	Grey -1.00	Stained -1.31
Steel	OK +.02	Med. stain -.07	Stained, spotted -.02
Aluminum	Black -.09	Black -.04	Black -.04
Cast Iron	Sl. stain +.09	Mod. stain +.05	Stained, spotted +.13
Brass	Sl. stain -.04	Sl. stain -.04	Mod. stain +.01
Copper	V. sl. stain +.02	Mod. - heavy stain +.02	Heavy stain +.21
CCL Rating	17	17	18
Remarks		*Heaters burned out test was discontinued.	

TABLE II

SIMULATED SERVICE TEST (CONTINUED)

Metal Components	Aluminum reservoir brass radiator	Cast iron pot - brass radiator	
Test Number	7	8	9
Coolant	50/50 O-A-548a distilled water	30/70 O-A-548a distilled water	30/70 O-A-548a *syn. hard water
Added Inhibitor	0.06% Na_2HPO_4 0.10% MBT 0.50% borax	0.084% Na_2HPO_4 0.14% MBT 0.70% borax	0.084% Na_2HPO_4 0.14% MBT 0.70% borax
Total Hours of Operation	2007	2000	2008
pH Before	7.46	7.92	7.82
pH After	7.40	7.88	7.68
RA Before	10.40	8.80	8.60
RA After	9.50	8.50	8.10
Visual Inspection and wt. change mg/sq cm			
Solder	Sl. pitting on edge -1.06	OK -.01	V. sl. stain -.19
Steel	OK +.03	OK +.01	OK -.02
Aluminum	Grey +.03	Grey-pitted -17.00	Black -1.11
Cast Iron	Sl. stain +.13	Sl. rusting +.07	OK +.06
Brass	Sl. stain +.05	Sl. stain +.03	Sl. stain -.02
Copper	Sl. stain +.08	Sl. stain +.32	Sl.-mod. stain +.02
CCL Rating	17	19	17
Remarks			*342 ppm as $CaCO_3$

TABLE II

SIMULATED SERVICE TEST (CONTINUED)

Metal Components	Cast iron reservoir brass radiator	Steel pot - brass radiator	
Test Number	10	11	12
Coolant	30/70 O-A-548a *ASTM corrosive water	30/70 O-A-548a distilled water	50/50 O-A-548a distilled water
Added Inhibitor	0.084% Na_2HPO_4 0.14% MBT 0.70% borax	Water contains 1.5% O-I-490	Water contains 1.5% O-I-490
Total Hours of Operation	2013	2021	2002
pH Before	7.82	7.92	7.55
pH After	7.78	7.82	7.55
RA Before	9.20	10.60	11.50
RA After	8.30	10.60	11.30
Visual Inspection and wt. change mg/sq cm			
Solder	Heavy stain -2.32	Heavy stain -.15	OK -.30
Steel	Heavy stain -.09	Mod. stain -.03	OK -.02
Aluminum	Black -.94	Yellow -10.31	Grey - green -6.17
Cast Iron	Mod. stain +.22	Mod. stain -.01	Sl. stain -.03
Brass	Sl. stain +.06	Mod. stain +.21	Sl. stain +.12
Copper	Heavy stain +.09	Heavy stain +.25	Mod. stain +.10
CCL Rating	23	21	19
Remarks	*100 ppm of Cl^-, $SO_4^=$ and HCO_3^-		

TABLE III

FIELD TEST

Test Vehicles	5 ton truck M-54 5C9073	5 ton truck M-54 5C9075
Coolant	30/70 O-A-548a/distilled water	30/70 O-A-548a/distilled water
Added Inhibitor	0.084% Na_2HPO_4 0.14% MBT 0.70% borax	0.084% Na_2HPO_4 0.14% MBT 0.70% borax
pH Initial	7.68	7.68
After 3 Weeks	7.60	7.62
After 6 Weeks	7.62	7.72
RA Initial	9.45	9.20
After 3 Weeks	9.20	9.00
After 6 Weeks	9.00	7.30
Freezing Point Initial	-13°F	-12°F
After 3 Weeks	-13°F	-12°F
After 6 Weeks	-16°F	- 4°F
Mileage After 3 Weeks	4,857	5,098
After 6 Weeks	10,482	9,300
Total Make-up Solution Added	None	*12 qts after 5 weeks
Remarks	Test discontinued after 6 weeks.	*Generator shaft broke in the field at 7,000 miles, the fan belt came off, radiator overheated and solution was lost. Test discontinued after 6 weeks.

TABLE III

FIELD TEST (CONTINUED)

Facility Vehicles	1960 Ford 1G6510	1960 Ford 1G6512
Coolant	30/70 O-A-548a/distilled water	30/70 O-A-548a/distilled water
Added Inhibitor	0.084% Na_2HPO_4 0.14% MBT 0.70% borax	0.084% Na_2HPO_4 0.14% MBT 0.70% borax
pH Initial	7.60	7.52
After 3 Months	7.52	7.45
After 7 Months	7.42	7.50
After 13 Months	7.38	----
After 15 Months	----	7.50
RA Initial	10.50	11.00
After 3 Months	9.85	10.40
After 7 Months	9.00	8.60
After 13 Months	7.60	----
After 15 Months	----	7.40
Freezing Point Initial	-15°F	-19°F
After 3 Months	-24°F	-30°F
After 7 Months	-23°F	-22°F
After 13 Months	-22°F	----
After 15 Months	----	-11°F
Mileage After 3 Months	12,470	12,560
After 7 Months	24,247	20,043
After 13 Months	33,910	----
After 15 Months	----	24,132
Total Make-up Solution Added	1 qt. added at 13 months.	1½ qts added at 15 months
Remarks	Test to date performing satisfactorily. Test continuing.	Test to date performing satisfactorily. Test continuing.

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